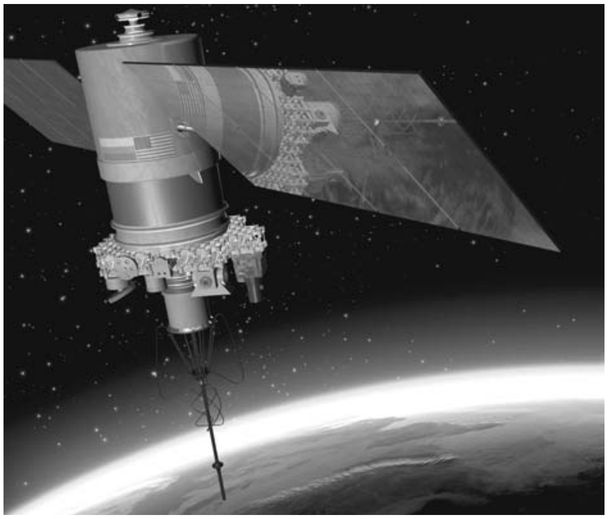
Meteor-3M



Meteor-3M URL
www-sage3.larc.nasa.gov/

Key Meteor-3M Facts

Spacecraft: Russian Meteor-3M

Orbit
Type: Sun-synchronous
Equatorial Crossing: 9:30 a.m.
Altitude: 1020 km ± 20 km
Inclination: 99.64°
Period: 105.3 minutes
Repeat Cycle: N/A

Dimensions: 7 m × 2 m × 2 m

Mass: 2,500 kg

Power: 600 W

Design Life: 5 years

Partners: RASA

Summary

The Stratospheric Aerosol and Gas Experiment (SAGE III) is the EOS component of the Russian Meteor-3M mission. SAGE III provides accurate, long-term measurements of ozone, aerosols, water vapor, and other key parameters of Earth's atmosphere.

Instruments

- SAGE III

Note: SAGE III is actually one of nine instruments on the Meteor-3M mission. However, the other instruments are not NASA instruments, and thus, are not described in this handbook.

Points of Contact

- *SAGE III Principal Investigator:* M. Patrick McCormick, Hampton University
- *SAGE III Project Scientist:* William Chu, NASA Langley Research Center
- *SAGE III Deputy Project Scientist:* Chip Trepte, NASA Langley Research Center

Other Key Personnel

- *SAGE III Program Scientist:* Phil DeCola, NASA Headquarters
- *SAGE III Program Executive:* Lou Schuster, NASA Headquarters
- *SAGE III Mission Manager:* Mike Cisewski, NASA Langley Research Center
- *SAGE III Program Manager:* Shahid Habib, NASA Goddard Space Flight Center

Mission Type

Earth Observing System (EOS) Systematic Measurements

Launch

- *Date and Location:* December 10, 2001, from Baikonur Cosmodrome, Russia

Relevant Science Focus Areas

(see NASA's Earth Science Program section)

- Atmospheric Composition
- Climate Variability and Change

Related Applications

(see Applied Sciences Program section)

- Air Quality
- Disaster Management

SAGE III Science Goals

- Provide global, long-term measurements of key components of Earth's atmosphere.
- Provide measurements of temperature in the stratosphere and mesosphere and profiles of trace gases, such as water vapor and nitrogen dioxide, that play significant roles in atmospheric radiative and chemical processes.

Meteor-3M Mission Background

Since the 1950s, it has become increasingly clear that human activities are modifying the composition of the atmosphere on a global scale. As the result of industrialization, the concentration of carbon dioxide has increased by about 20% since 1950. More recently, the stratospheric concentrations of chemically active gases containing chlorine, bromine, and fluorine have dramatically increased. These trends have created issues of global interest including global warming and declining levels of ozone (both globally and in the ozone 'hole' in the Antarctic). It has become evident, however, that these processes do not occur independently of one another and can only be understood in the context of a global system. Accurate and precise measurements are needed to unravel complex and interactive relationships between chemical, radiative, and dynamical processes in the atmosphere, ocean, and on land.

The Russian Aviation and Space Agency (RASA) assembled a mission to measure temperature and humidity profiles, clouds, surface properties, and high-energy particles in the upper atmosphere. The Meteor-3M spacecraft is an advanced model of the Meteor spacecraft that was developed over 30 years ago. Included among the instruments on Meteor-3M is the Third Stratospheric Aerosol and Gas Experiment (SAGE III). The Meteor-3M mission, along with the SAGE III mission, was terminated on March 6, 2006, because of a power supply system failure resulting in loss of communication with the satellite.

SAGE III

Stratospheric Aerosol and Gas Experiment

The SAGE III instrument provides long-term measurements of key components of Earth's atmosphere that are important in helping scientists understand how natural processes and human activities influence our climate. The most important of these are the vertical distribution of aerosols and ozone from the upper troposphere through the stratosphere. In addition, SAGE III also provides unique measurements of temperature in the stratosphere and mesosphere and profiles of trace gases such as water vapor and nitrogen dioxide that play significant roles in atmospheric radiative and chemical processes. SAGE III makes long-term measurements of these key components and provides the congruent aerosol and gaseous data important to radiative and atmospheric chemistry studies.

Key SAGE III Facts

Heritage: SAM II, SAGE I, SAGE II

Instrument Type: Grating spectrometer

Scan Type: Solar and lunar occultation

Calibration: Self-calibrating solar and lunar occultation, with measurements within nine spectral regions between (290-1,550 nm), to study aerosols, O_3, OClO, NO_2, NO_3, H_2O, temperature, and pressure

Swath: N/A (looks at the Sun and/or moon through Earth's limb)

Spatial Resolution: 1–2 km vertical

Dimensions: 73 cm × 45 cm × 93 cm

Mass: 76 kg

Duty Cycle: During solar and lunar Earth occultation

Power: 80 W (average)

Data Rate: 115 kbps

Thermal Control: Passive, heaters, and thermal-electric cooler

Thermal Operating Range: 10–30° C

FOV: ±185° azimuth, 13–31° elevation, dependent on orbital altitude

Instrument IFOV: < 0.5 km vertical at 20-km tangent height

Pointing requirements (platform+instrument, 3σ):
Control: 1°
Knowledge: 0.25°/axis
Stability: 30 arcsec/s per axis

Responsible Center: NASA LaRC

Partner: Ball Aerospace

SAGE III is a grating spectrometer that measures ultraviolet/visible energy. It relies upon the flight-proven designs used in the Stratospheric Aerosol Measurement (SAM I) and SAGE I and II instruments. The new SAGE III design incorporates charge coupled device (CCD)-array detectors and a 16-bit A/D converter. The additional wavelengths and the ability to operate during both lunar and solar occultation have several benefits, as they: improve aerosol characterization and gaseous retrievals of O_3, H_2O, and NO_2; add retrievals of temperature, pressure, NO_3 and OClO; extend the vertical range of measurements; provide a self-calibrating instrument independent of any external data; and expand the sampling coverage. The global scientific community uses the information obtained from SAGE III to help improve their understanding of Earth's climate, of climate change, and human-induced ozone trends.

The science objectives of SAGE III are to:

- Retrieve global profiles (with 1-to-2-km vertical resolution) of atmospheric aerosols, O_3, H_2O, NO_2, NO_3, OClO, temperature, and pressure in the mesosphere, stratosphere, and troposphere.
- Investigate the spatial and temporal variability of the measured species in order to determine their role in climatological processes, biogeochemical cycles, the hydrologic cycle, and atmospheric chemistry.
- Characterize tropospheric and stratospheric aerosols and upper tropospheric and stratospheric clouds, and investigate their effects on Earth's environment, including radiative, microphysical, and chemical interactions.
- Extend the SAM II, SAGE I, and SAGE II self-calibrating solar-occultation data sets (begun in 1978), enabling the detection of long-term trends.
- Provide atmospheric data essential for the calibration and interpretation/correction of other satellite sensors, including EOS and ground-based sensors.

As indicated above, SAGE III takes advantage of both solar and lunar occultations to measure aerosol and gaseous constituents of the atmosphere. Most of the objectives rely on the solar-occultation technique, which involves measuring the effects of extinction of solar energy by aerosol and gaseous constituents in the spectral region 0.29–1.55 µm during spacecraft sunrise and sunset events. For example, during a sunset event, exoatmospheric solar-limb data are obtained when the Sun-satellite vector is high above the Earth's atmosphere. As the Sun sets, a series of scans through the atmosphere is performed during which measurements of the solar transmission through the atmosphere are made. Because all atmospheric measurements are ratioed to the exoatmospheric solar-limb profiles taken during the same event, the instrument is nearly self-calibrating, and the retrieved data are not susceptible to long-term instrument degradation.

The moon is used as another source of light for occultation measurements. In the spectral region 0.4–0.95 µm, the moon has a relatively flat, i.e., grey, albedo. By taking a ratio of an appropriate set of exoatmospheric scans of the moon to an appropriate set of exoatmospheric scans of the Sun, the structure in the solar spectrum is retrieved and the average lunar spectral albedo is obtained. This average lunar spectral albedo can be used along with the extinction cross sections of all absorbing species to determine an optimal fit to the measurements.

Meteor-3M References

Chu, W. P., and L. E. Mauldin III, 1999: Overview of SAGE III experiment, in A. M. Larar, ed., *Proc. SPIE 3756, Optical and Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research III*, 102–109.

Chu, W. P., C. R. Trepte, J. M. Zawodny, L. W. Thomason, M. S. Cisewski, D. Rault, G. Taha, R. Moore, and D. Risley, 2003: First year measurements of Stratospheric Aerosol and Gas Experiment III/Meteor, in A. M. Larar, J. A. Shaw, and Z. Sun, eds., *Proc. SPIE 5157, Optical Spectroscopic techniques and Instrumentation for Atmospheric and Space Research V*, 42–46.

McCormick, M. P., 1991: SAGE III capabilities and global change. Paper 91-0051, 29th Aerospace Sciences Meeting, 7-10 January 1991, Reno, Nevada, American Institute of Aeronautics and Astronautics, Washington, DC.

Meteor-3M Data Products

Product Name or Grouping	Processing Level	Coverage	Spatial/Temporal Characteristics
SAGE III *Data Set Start Date: February 27, 2002, Data Set End Date: March 6, 2006*			
Level 1B Transmission (≥ 80 wavelengths) Solar Events	1B	Global, for altitudes of 0–100 km	1.5 km horizontal resolution (hres) (Solar), 0.5 km vertical resolution (vres)/ 28 solar events daily
Aerosol Extinction Stratospheric Optical Depth (at 8 wavelengths) Aerosol to molecular extinction at 1020 nm (Solar only)	2	Global, 0–30 km	1.5 km hres (Solar), 0.5 km vres/ 28 solar events daily
Cloud Presence	2	Global, 6–30 km	1.5 km hres (Solar), 0.5 km vres/ 28 solar events daily
H_2O Concentration	2	Global, 0–50 km	1.5 km hres (Solar), 0.5 km vres/ 28 solar events daily
NO_2 Concentration	2	Global, 10–50 km	1.5 km hres (Solar), 3.5 km hres (Lunar), 0.5 km vres/28 solar events daily
NO_2 Slant Path Column Amount	2	Global, 10–50 km	1.5 km hres (Solar), 3.5 km hres (Lunar), 0.5 km vres/28 solar events daily
NO_3 Concentration (Lunar Only)	2	Global, 20–55 km	3.5 km hres (Lunar), 0.5 km vres
O_3 Concentration	2	Global, 6–85 km	1.5 km hres (Solar), 3.5 km hres (Lunar), 0.5 km vres/28 solar events daily
O_3 Slant Path Column Amount	2	Global, 50–85 km	1.5 km hres (Solar), 3.5 km hres (Lunar), 0.5 km vres/30 solar events daily
OClO Concentration	2	Global, 15–25 km	3.5 km hres (Lunar), 0.5 km vres
Pressure	2	Global, 0–85 km	1.5 km hres (Solar), 3.5 km hres (Lunar), 0.5 km vres
Temperature Profile (Solar only)	2	Global, 0–85 km	1.5 km hres, 0.5 km vres

Meteor-3M Data Products